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(54) **ENGINE FOR PERSONAL WATERCRAFT  
AND CRANKSHAFT THEREOF**

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123/90.31

(58) **Field of Search** ..... 123/195 A, 90.31

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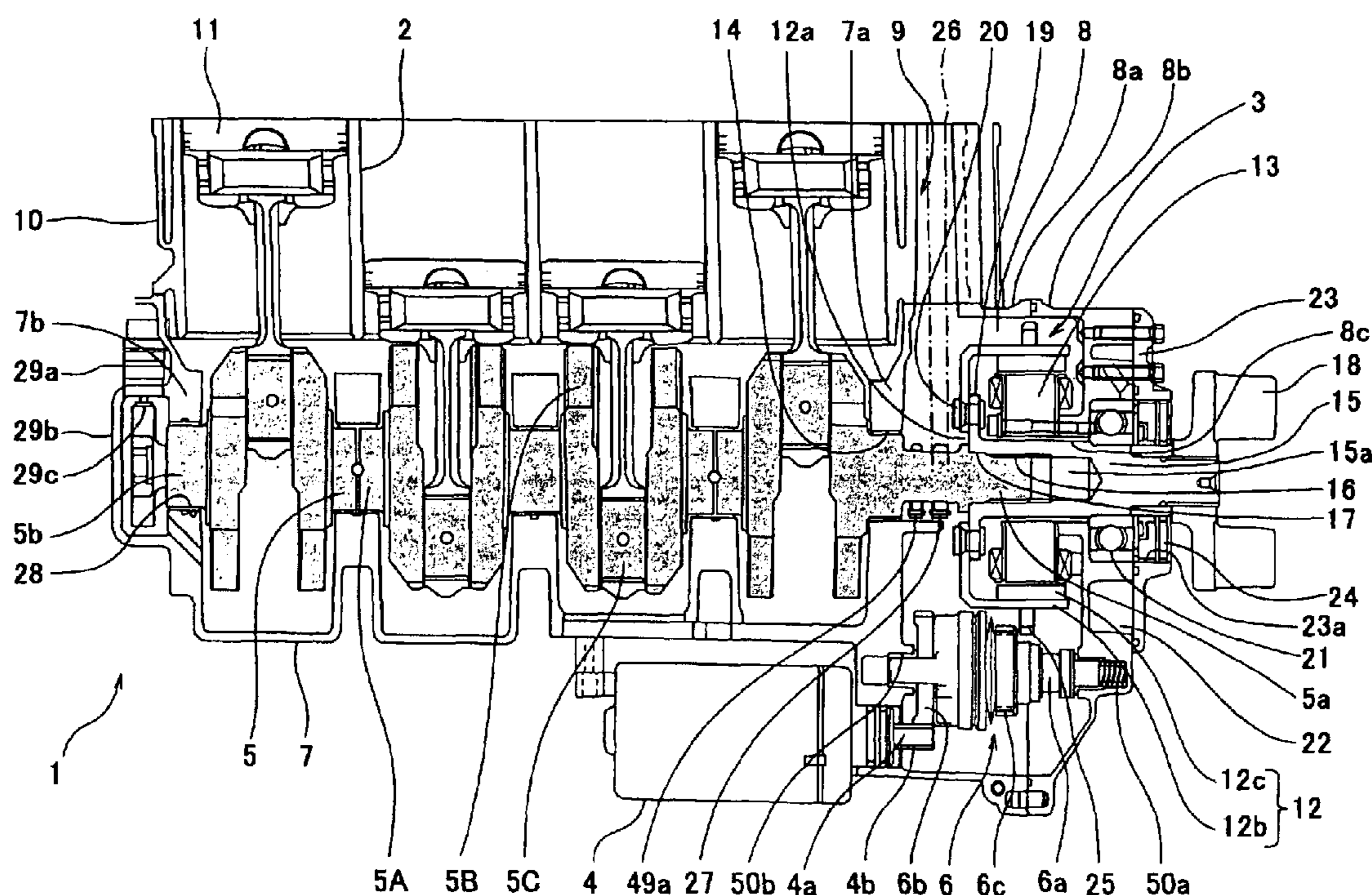
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(57) **ABSTRACT**

Disclosed is an engine of a personal watercraft having a water jet pump at a rear end thereof, in which a center of gravity of the engine is located rearward for improvement of planing capability of the watercraft. The engine comprises: a crankcase having a front end wall and a rear end wall; a crankshaft provided inside the crankcase; a generator provided at an output end portion of the crankshaft, the generator including a rotor fixed to the crankshaft; a starter motor provided on an output end side of the crankshaft outside the crankcase; and a clutch provided between the starter motor and the rotor of the generator, for connecting/disconnecting the starter motor to/from the rotor.

**10 Claims, 6 Drawing Sheets**



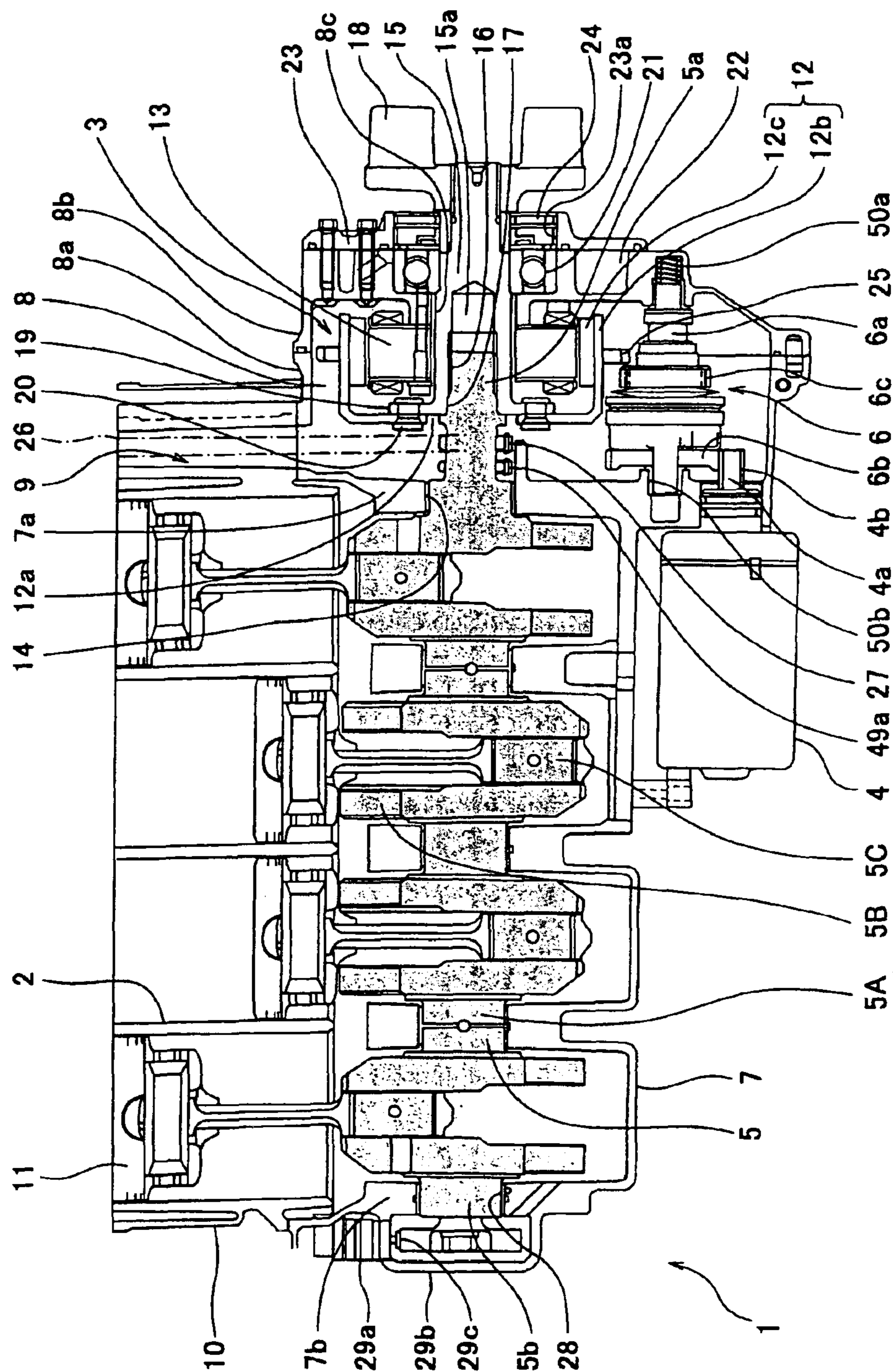


Fig. 1

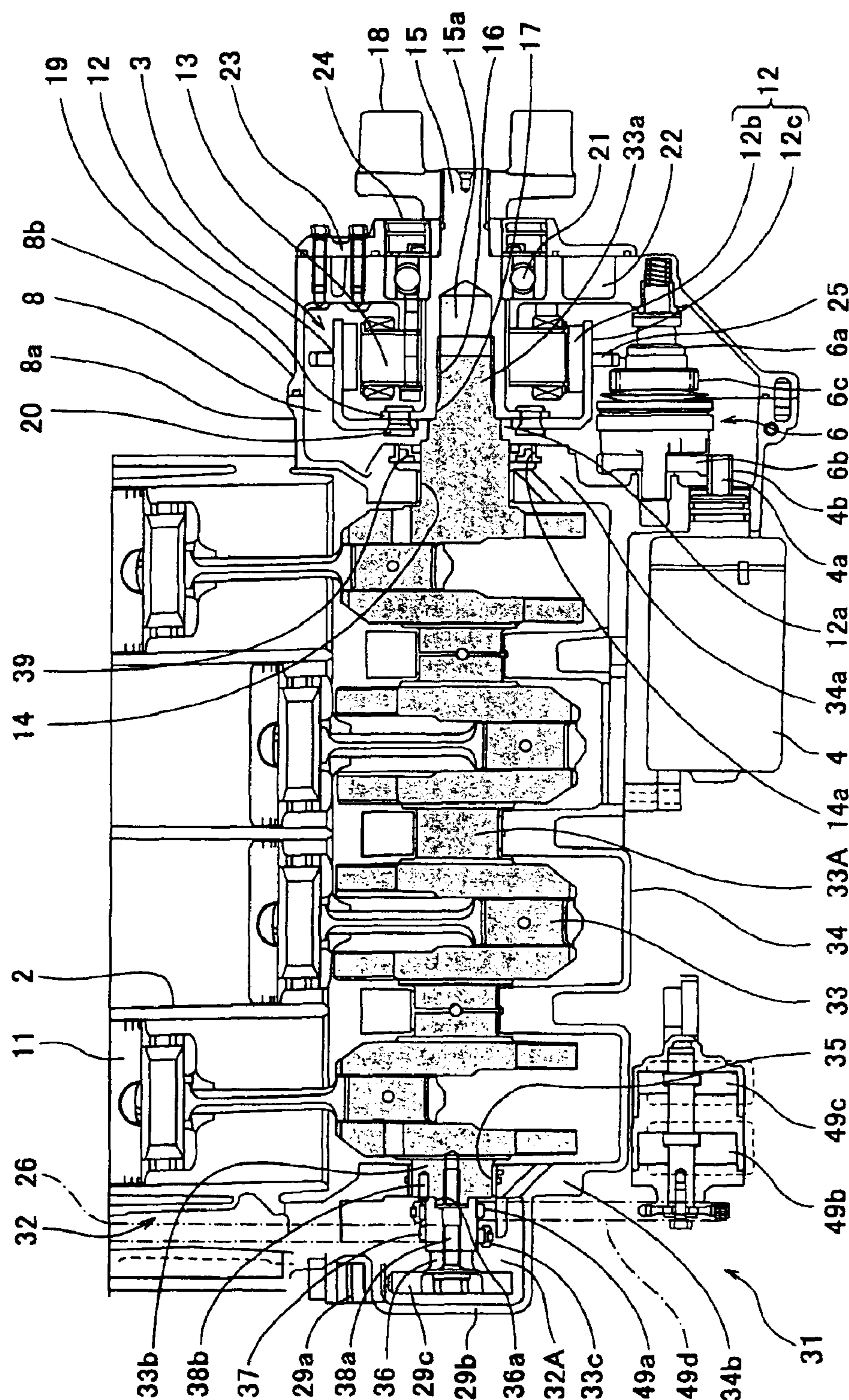


Fig. 2

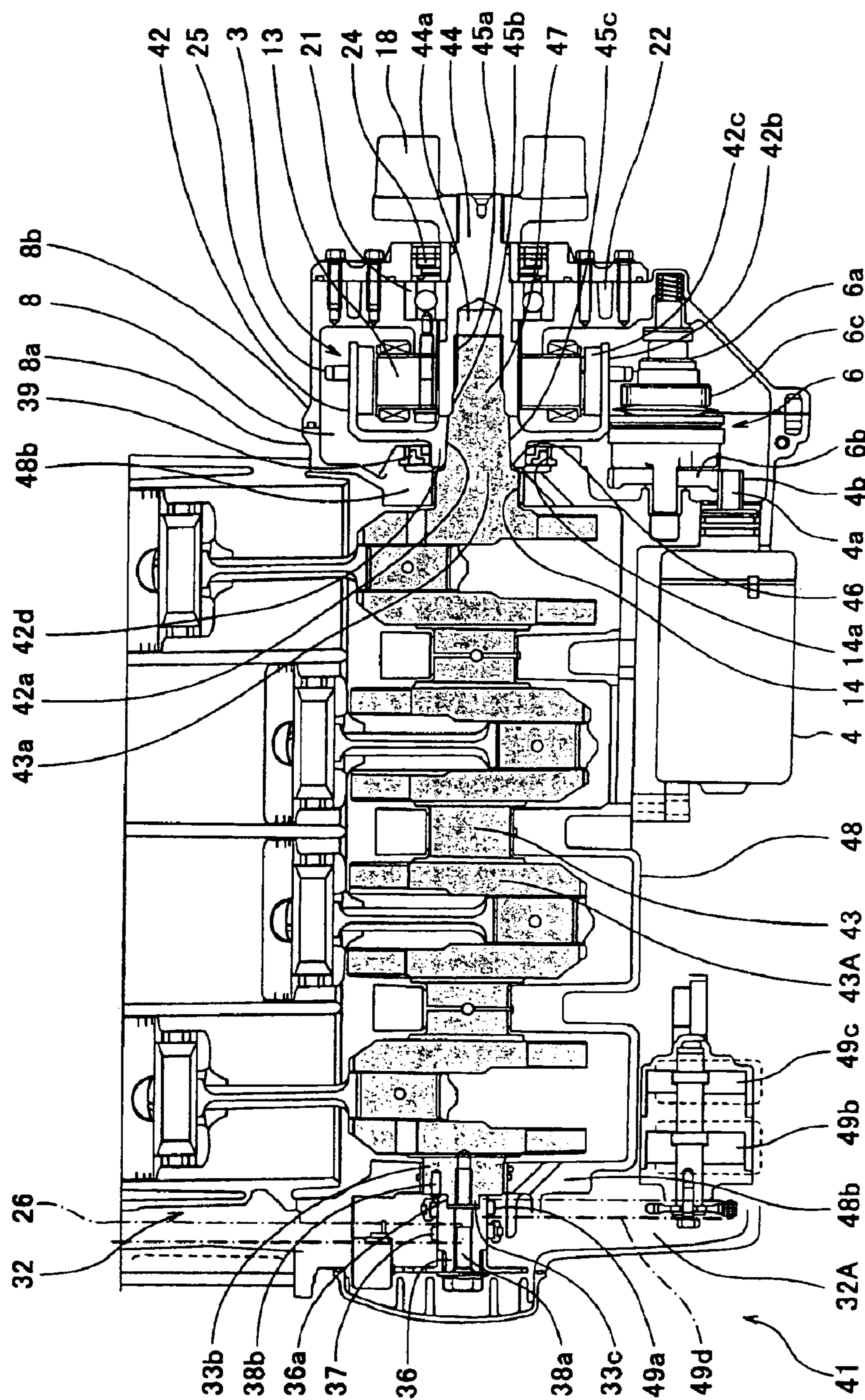


Fig. 3

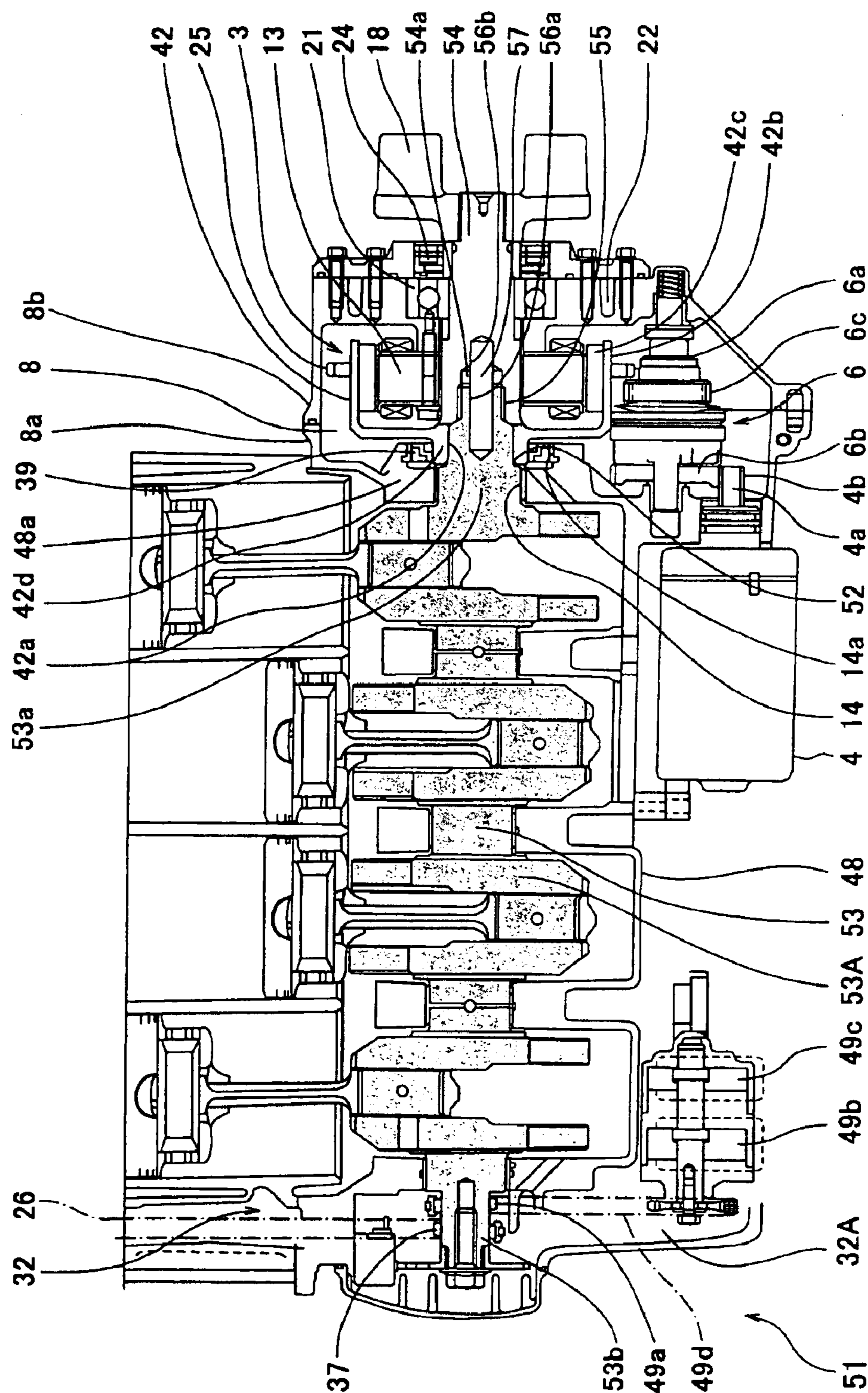


Fig. 4

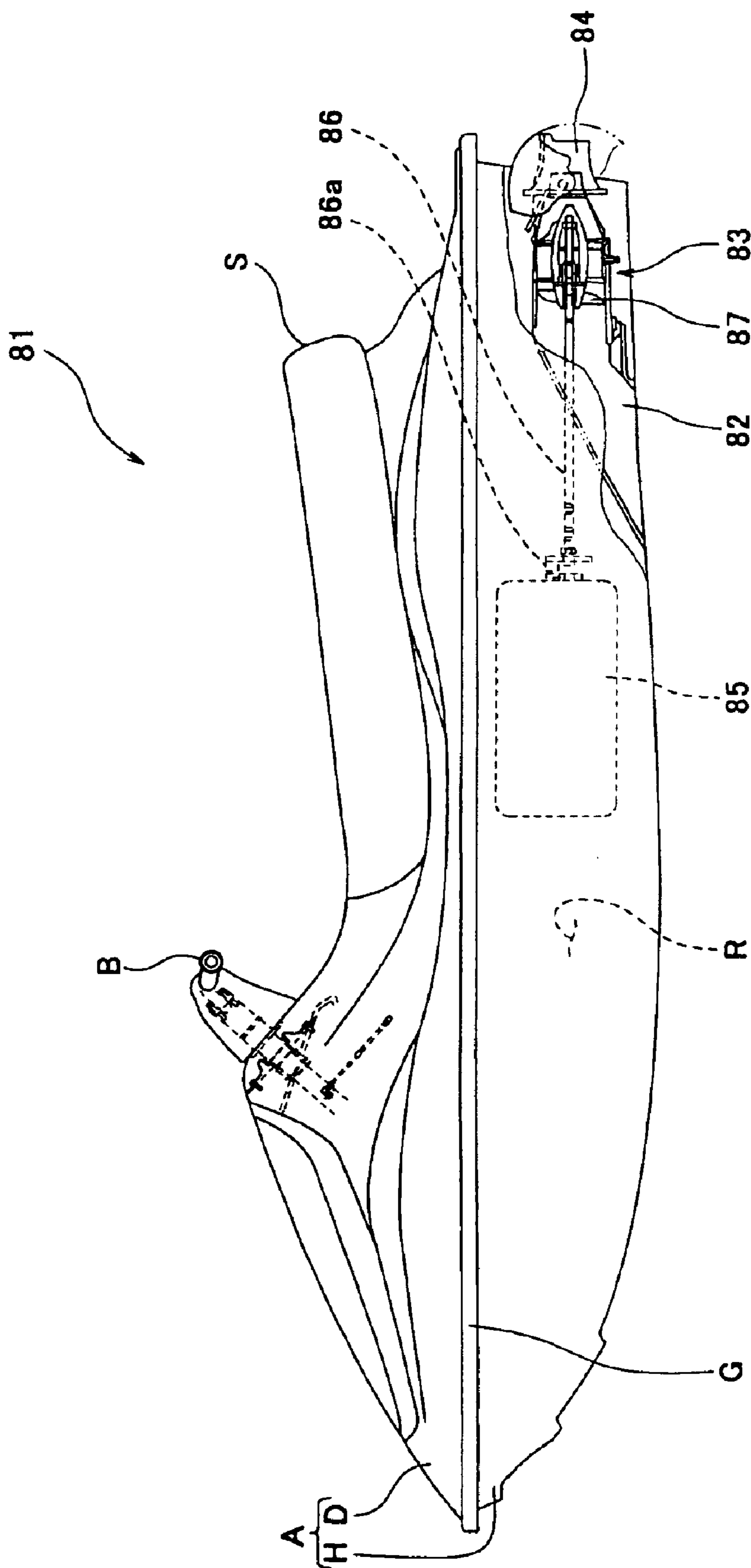
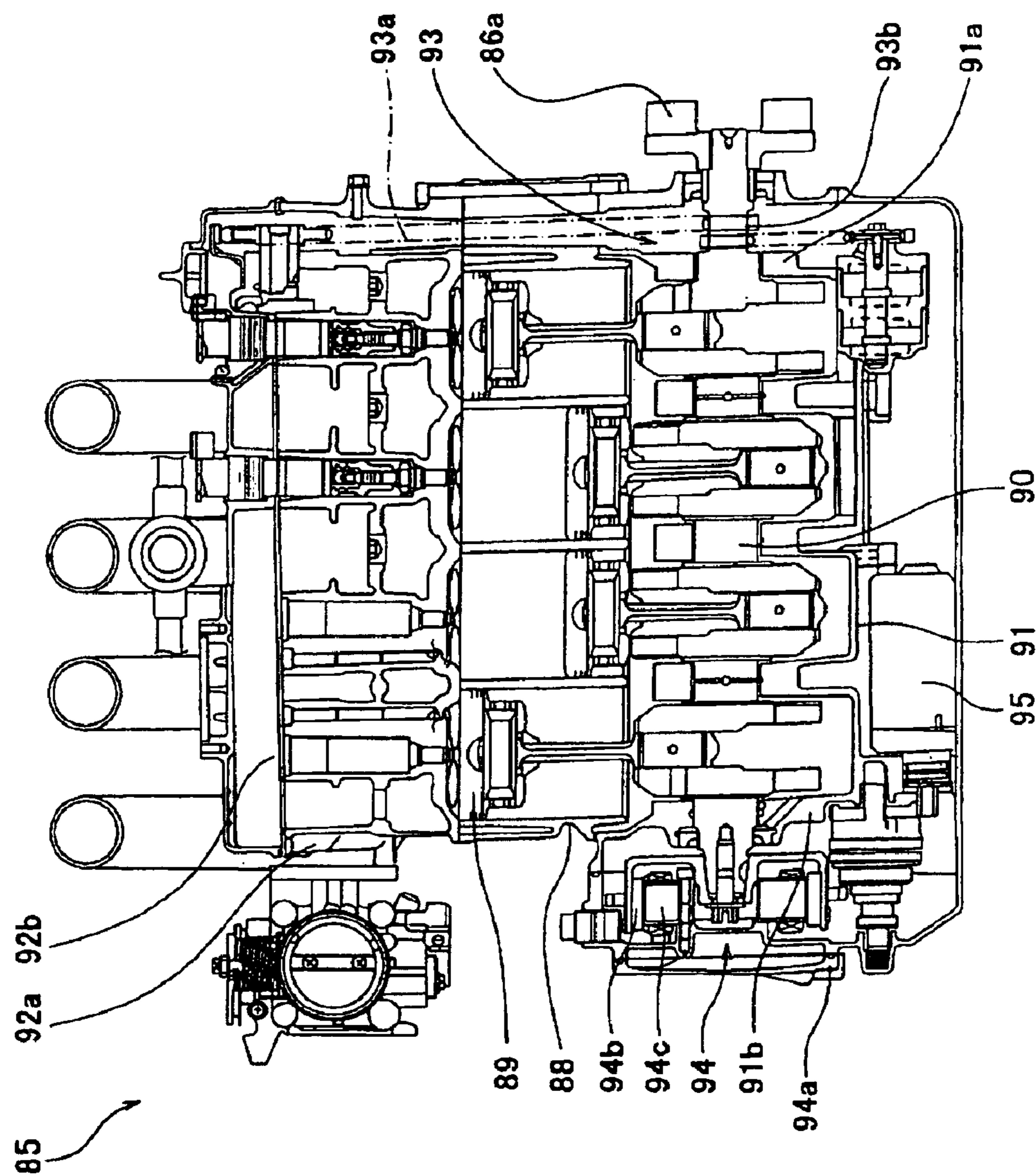


Fig. 5



PRIOR ART

Fig. 6

# ENGINE FOR PERSONAL WATERCRAFT AND CRANKSHAFT THEREOF

## BACKGROUND OF THE INVENTION

### Field of the Invention

The present invention relates to an engine for a personal watercraft and a crankshaft thereof. More particularly, the present invention relates to an engine mounted in a body for driving a propulsion device of a personal watercraft that ejects water rearward and planes on a water surface as the resulting action, and a crankshaft suitable for the engine.

In recent years, so-called jet-propulsion personal watercraft (PWC) have been widely used in leisure, sport, rescue activities, and the like. FIG. 5 shows an example of such personal watercraft.

In a personal watercraft **81** in FIG. 5, **A** denotes a body of the watercraft. The body **A** comprises a hull **H** and a deck **D** covering the hull **H** from above. A line at which the hull **H** and the deck **D** are connected over the entire perimeter thereof is called a gunnel line **G**. **L** denotes a waterline in a state of the watercraft.

A straddle-type seat **S** is mounted onto an upper surface of the body **A** so as to extend substantially from a center portion to a rear portion over the deck **D** along the longitudinal direction of the watercraft **81**. Straddling the straddle-type seat **S**, the rider grips a steering handle **B** located forward of the seat **S** and steers the watercraft. Hereinafter, "forward" refers to the direction toward which the watercraft moves and "rearward" refers to the opposite side.

The personal watercraft **81** is configured to have a water jet pump **83** that pressurizes and accelerates water sucked from a water intake **82** generally provided on a hull bottom surface of the body **A** and ejects the water rearward through a steering nozzle **84**. Thereby, the body **A** is propelled. An engine **85** for driving the water jet pump **83** is contained in an engine room **R** located below the seat **S**. A propeller shaft **86** is connected to an output shaft of the engine **85** and an impeller **87** of the water jet pump **83** is attached on the propeller shaft **86**.

Commonly, a two-cycle engine is mounted in the personal watercraft as the engine **85**. Recently, in addition to this, the use of a four-cycle engine has been proposed.

FIG. 6 shows an example of the four-cycle engine. The engine **85** is a four-cylinder engine and is placed such that cylinders are arranged along the longitudinal direction of the body **A** (FIG. 5). Reference numeral **88** denotes a cylinder, **89** denotes a piston, **90** denotes a crankshaft, **91** denotes a crankcase, **92a** denotes a cylinder head, and **92b** denotes a head cover. A cam chain tunnel **93** is formed in a rear end portion of the engine **85**, and a generator **94** and a starter motor **95** are mounted in a front end portion of the engine.

A rear end portion of the crankshaft **90** of the engine **85** penetrates through a rear end wall **91a** of the crankcase **91** and penetrates through the cam chain tunnel **93** so as to protrude outwardly in the rear end of the engine **85**. A coupling **86a** for connecting the propeller shaft **86** (FIG. 5) is mounted to the rear end of the crankshaft **90**. A sprocket **93b** for a cam chain **93a** is mounted to a position of the crankshaft **90** inside the cam chain tunnel **93**. Meanwhile, a front end portion of the crankshaft **90** penetrates through a front end wall **91b** of the crankcase **91** and protrudes into a housing **94a** covering the generator **94**. A rotor **94b** of the generator **94** is mounted to the front end portion of the crankshaft **90**. A stator **94c** of the generator **94** is fixed to the housing **94a**.

Since the above-structured engine has weight more than that of the two-cycle engine, it is desirable to position the engine in the personal watercraft so as to minimize the effect of the engine having more weight on cruising attitude of the watercraft. However, since placement of the engine is restricted by the space of the engine room of the personal watercraft, it is difficult to greatly change the position of the engine. For the purpose of improvement of the cruising attitude of the personal watercraft, it is desirable to locate a center of gravity of the four-cycle engine closest to the rear of the personal watercraft.

In order to obtain a power as high as that of the two-cycle engine in the four-cycle engine without an increase in displacement of the engine, increases in an engine speed and the number of cylinders are effective.

However, with the increase in the number of the cylinders, it becomes necessary to increase the length of the crankshaft **90**. It would be difficult to manufacture a longer crankshaft in the conventional manufacturing apparatus, and therefore, there arises a need for a manufacturing apparatus capable of manufacturing the longer crankshaft. But, the manufacturing apparatus of the crankshaft having a complex shape and requiring high accuracy would be complex and expensive.

## SUMMARY OF THE INVENTION

The present invention addresses the above-described conditions, and an object of the present invention is to provide an engine having a center of gravity located rearward to be suitable for a personal watercraft, and a crankshaft suitable for the engine.

According to the present invention, there is provided an engine of a personal watercraft having a water jet pump at a rear end thereof, comprising: a crankcase having a front end wall and a rear end wall; a crankshaft provided inside the crankcase; a generator provided at an output end portion of the crankshaft, the generator including a rotor fixed to the crankshaft; a starter motor provided on an output end side of the crankshaft outside the crankcase; and a clutch provided between the starter motor and the rotor of the generator, for connecting/disconnecting the starter motor to/from the rotor.

With such a structure, since the generator, the starter motor, the clutch and the like of the engine, which have relatively large weight, are located on the output end side of the engine, a center of gravity of the engine is advantageously located rearward in the engine so as to be suitable for the watercraft. Since the generator and the starter motor are placed on the output end side of the engine, the clutch is correspondingly placed on the output end side of the engine. As defined herein, the output end side refers to the rear side of the engine.

Preferably, the engine may further comprise: a cam chain tunnel formed in a front portion of the front end wall of the crankcase on an opposite side of the output end side of the crankshaft; and a sprocket for driving a cam mechanism of the engine, the sprocket being mounted to an end portion of the crankshaft passing through a penetrating hole formed in the front end wall of the crankcase and protruding into the cam chain tunnel.

With such a structure, the diameter of the sprocket can be selected irrespective of the diameter of output end side of the crankshaft adapted to transmit an output of the crankshaft to the propeller shaft. This reduces the diameter of the sprocket. As a result, a lightweight and compact engine is achieved. Therefore, for the watercraft, it is preferable to place the cam chain on the opposite side (front end side of the engine) of the output side of the crankshaft.

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Preferably, the engine may further comprise: a generator chamber formed in a rear portion of the rear end wall of the crankcase, for containing the generator, the output end portion of the crankshaft may pass through a penetrating hole formed in the rear end wall of the crankcase and protrudes into the generator chamber, and a seal member may be provided in the penetrating hole of the crankcase to seal between an inside of the crankcase and the generator chamber. In this structure, since an oil inside the crankcase is prevented from flowing into an inside of the generator chamber, the loss of a rotational energy of the rotor of the generator which would be caused by viscosity of the oil is avoided.

Preferably, the engine may further comprise a water jacket formed in a housing constituting the generator chamber to allow cooling water to flow therethrough. With this structure, the generator and its vicinity are cooled more effectively.

The engine may comprise a generator chamber formed in a rear portion of the rear end wall of the crankcase, for containing the generator; a cam chain tunnel communicating with an inside of the generator chamber; and a sprocket for driving a cam mechanism, the sprocket being mounted to a portion of the crankshaft between the rotor and the penetrating hole in the generator chamber, and the rotor is mounted to the output end portion of the crankshaft passing through a penetrating hole formed in the rear end wall of the crankcase and protruding into the generator chamber. Such a structure is advantageous in that the generator and its vicinity are efficiently cooled by the oil dropping through the cam chain tunnel although a slight loss of the rotational energy of the rotor of the generator occurs due to the oil.

According to the present invention, there is provided a crankshaft of an engine for a personal watercraft, comprising: a crankshaft body; a first extended shaft member connected to one end portion of the crankshaft body so as to be rotatable integrally with and separable from the crankshaft body; and a rotor-mounting portion provided at an end portion of the crankshaft on the first extended shaft member side, for mounting a rotor of a generator of the engine, and the first extended shaft member constitutes an output end part of the engine.

With such a structure, the crankshaft body is shortened. Consequently, manufacturing the crankshaft becomes easy. In addition, the generator can be easily placed in the output end side of the crankshaft.

Preferably, the rotor-mounting portion may be formed integrally with the first extended shaft member. With this structure, the rotor of the generator is easily placed on the output end side of the crankshaft.

Preferably, the crankshaft body may comprise an extended shaft mounting portion for connecting the first extended shaft member and the rotor-mounting portion in this order as seen from the one end portion of the crankshaft body, and the first extended shaft member may be mounted to the extended shaft mounting portion to thereby allow the rotor of the generator to be fixed to the rotor-mounting portion. With this structure, the rotor of the generator is easily placed on the output end side of the crankshaft.

The crankshaft may further comprise a coupling for taking out an output of the engine, the coupling being provided at a rear end portion of the first extended shaft member. Thereby, the output of the engine can be easily taken out.

Preferably, the crankshaft may further comprise a second extended shaft member connected to the other end portion of

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the crankshaft body to be rotatable integrally with and separable from the crankshaft body; and a sprocket-mounting portion for mounting a cam-driving sprocket on the second extended shaft member. With this structure, the crankshaft body is shortened, and therefore manufacturing the crankshaft becomes easy. The crankshaft is applied to an engine having a cam chain tunnel at a front portion thereof.

The crankshaft may comprise: a sprocket-mounting portion formed at the one end portion of the crankshaft body adjacent the first extended shaft member, for mounting a cam-driving sprocket of the engine. Such a crankshaft is suitably used in the engine having the cam chain tunnel communicating with an inside of the generator.

Preferably, in the crankshaft, a connecting hole may be formed in an end portion of the first extended shaft member for connecting the crankshaft body by inserting the one end portion of the crankshaft body thereinto, an outer peripheral face of the one end portion of the crankshaft body and an inner peripheral face of the connecting hole of the first extended shaft member may respectively have a cylindrical fitting face for centering, and an engagement portion for preventing circumferential relative rotation between the crankshaft body and the first extended shaft member. A center axis of the fitting face of the crankshaft body corresponds with a rotational center axis of the crankshaft and a center axis of the fitting face of the first extended shaft member corresponds with a center axis of the first extended shaft member. With such a structure, the crankshaft body can be made shorter.

According to the present invention, there is provided an engine of a personal watercraft comprising: a crankcase having a front end wall and a rear end wall; a crankshaft provided inside the crankcase; a generator provided at an output end portion of the crankshaft, the generator including a rotor fixed to the crankshaft; a starter motor provided on an output end side of the crankshaft outside the crankcase; a clutch provided between the starter motor and the rotor of the generator, for connecting/disconnecting the starter motor to/from the rotor, the crankshaft includes: a crankshaft body; a first extended shaft member having a tip end portion and a base end portion and connected to an end portion of the crankshaft body so as to be rotatable integrally with and separable from the crankshaft body; and a rotor-mounting portion provided at an end portion of the crankshaft on the first extended shaft member side, for mounting the rotor of the generator, and the first extended shaft member constitutes an output end part of the engine. With this structure, the center of gravity of the engine is located rearward to be suitable for the personal watercraft, and manufacturing the engine becomes easy.

The above and further objects and features of the invention will be more fully apparent from the following detailed description with accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view showing a portion including a crankshaft of an engine for a personal watercraft according to an embodiment of the present invention;

FIG. 2 is a longitudinal sectional view showing a portion including a crankshaft of an engine for a personal watercraft according to another embodiment of the present invention;

FIG. 3 is a longitudinal sectional view showing a portion including a crankshaft of an engine for a personal watercraft according to another embodiment of the present invention;

FIG. 4 is a longitudinal sectional view showing a portion including a crankshaft of an engine for a personal watercraft according to another embodiment of the present invention;

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FIG. 5 is a partially cross-sectional side view showing an example of a personal watercraft capable of mounting the engine of the present invention or the conventional engine; and

FIG. 6 is a longitudinal sectional view showing the conventional engine of the personal watercraft.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, embodiments of an engine of a personal watercraft of the present invention will be described with reference to the accompanying drawings.

FIG. 1 is a longitudinal sectional view showing main components including a crankshaft of an engine of a personal watercraft according to an embodiment of the present invention.

An engine 1 of this embodiment is a multi-cylinder (for example, four-cylinder) four-cycle engine. The engine 1 is mounted in the watercraft such that cylinders 2 are arranged along the longitudinal direction of a body of the watercraft (not shown) like the conventional engine 85 (see FIG. 6). Therefore, a crankshaft 5 of the engine 1 is placed along the longitudinal direction of the body and an output end portion thereof is connected to a propeller shaft of the watercraft (not shown). The propeller shaft functions to drive a water jet pump provided at a rear portion of the watercraft. The propeller shaft extends rearwardly from the output end portion of the crankshaft 5 and is connected to the water jet pump.

In the engine 1, a generator 3, a starter motor 4, and a clutch 6 for connecting/disconnecting the starter motor 4 to/from the crankshaft 5 are located in the vicinity of the rear end of the engine 1. Here, "front" refers to the direction toward which the body of the watercraft moves and "rear" refers to the opposite direction. More specifically, a coupling 18 for connecting the propeller shaft mentioned later is located on the "rear" side.

In FIG. 1, reference numeral 7 denotes a crankcase, 8 denotes a generator chamber that contains the generator 3, 9 denotes a cam chain tunnel, 10 denotes a cylinder block, and 11 denotes a piston. A cylinder head and a cylinder head cover provided over the cylinder block 10 are not illustrated in FIG. 1. The clutch 6 is accommodated in the generator chamber 8 together with a rotor 12 of the generator 3 and a stator 13 of the engine. The generator chamber 8 is comprised of a body portion 8a formed integrally with the crankcase 7 so as to open outside at a rear end thereof, and a first lid member 8b removably attached to the body portion 8a to close the open part of the body portion 8a.

A cam chain tunnel 9 that contains a cam chain 26 is provided in a rear portion of a rear end wall 7a of the crankcase 7. The cam chain tunnel 26 extends from the body portion 8a of the generator chamber 8 to the cylinder head (not shown) through an inside of the cylinder block 10. The cam chain 26 serves to transmit rotation of the crankshaft 5 to a camshaft provided on the cylinder head. The crankshaft 5 comprises a crankshaft body 5A (expressed as colored in FIG. 1) having a crank web 5B, a crank pin 5C and the like, and a first extended shaft member 15 as an output end part of the crankshaft 5.

A rear end portion 5a of the crankshaft body 5A passes through a penetrating hole 14 formed in a rear end wall 7a of the crankcase 7 so as to be rotatably supporting the crankshaft 5 and protrudes into an inside of the generator chamber 8. The rear end portion 5a has a screw portion 16. The screw portion 16 is screwed into an inner thread formed

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in a connecting hole 15a of the first extended shaft member 15 such that the first extended shaft member 15 can rotate integrally with the crankshaft body 5A. Alternatively, the first extended shaft member 15 may be connected to the crankshaft body 5A so as to be integrally rotatable by any suitable means, including by a spline connection. In this embodiment, in the portion where the rear end portion 5a is fitted to the first extended shaft member 15, the screw portion 16 is formed on a rear end side of the rear end portion 5a and a centering location portion 17 is formed adjacent a front end side of the screw portion 16 (on the opposite side of the rear end side). In the centering location portion 17, an outer peripheral face of the rear end portion 5a is fitted to a corresponding inner peripheral face of the connecting hole 15a of the first extended shaft member 15 without substantial clearance. The outer peripheral face of the rear end portion 5a and the corresponding inner peripheral face of the first extended shaft member 15 are respectively formed concentrically with a rotational center axis of the crankshaft 5.

The first extended shaft member 15 passes through a penetrating hole 8c formed in the first lid member 8b of the generator chamber 8 and protrudes outwardly. The coupling 18 for connecting the propeller shaft (not shown) is connected by a spline to a rear end portion (output end portion) of the outwardly protruding first extended shaft member 15. The portion where a spline groove is formed constitutes a coupling mounting portion. The rotor 12 of the generator 3 is mounted to an outer periphery of a portion of the first extended shaft member 15 which is located inside the generator chamber 8 so as to be integrally rotatable. More specifically, an outwardly extending flange 19 of a circular-ring shape is formed at an outer periphery of a front end of the first extended shaft member 15. The rotor 12 is of a cylinder shape having a bottom and is mounted to the flange 19 by means of a rivet 20. An opening 12a is formed in the bottom of the rotor 12 to allow the rear end portion 5a of the crankshaft body 5A to be inserted therinto. A magnet 12c is fixed to the inner peripheral face of a cylindrical body portion 12b of the rotor 12.

A stator 13 of the generator 3 is removably mounted to the first lid member 8b of the generator chamber 8. The penetrating hole 8c formed in the first lid member 8b has an increased diameter in a rear portion thereof and a bearing 21 is mounted in the increased-diameter portion for rotatably supporting the first extended shaft member 15. A concave portion 22 is formed in an outer face of the first lid member 8b to allow cooling water to flow therethrough. A second lid member 23 is removably attached to close the concave portion 22. In this embodiment, the concave portion 22 is circularly formed in the first lid member 8b around the bearing 21, and constitutes a water jacket for introducing the cooling water. The water jacket serves to cool the generator 3, the bearing 21, an oil dropping from the cam chain tunnel 9, and the like. A seal member 24 is provided in a penetrating hole 23a of the second lid member 23, through which the first extended shaft member 15 penetrates.

The water jacket of this embodiment is formed in the rear end wall of the first lid member 8b to surround the bearing 21. Instead, the water jacket may be provided at an outer peripheral wall of the generator chamber 8 or the like, as necessary.

The clutch 6 is accommodated in the generator chamber 8 in such a manner that both ends of a shaft 6a of the clutch 6 are supported by support holes 50a, 50b formed in the crankcase 7 and the first lid member 8b, respectively. An output shaft 4a of the starter motor 4 mounted to an outer

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face of the side wall at the rear portion of the crankcase 7 protrudes into the generator chamber 8. A gear 4b provided on the output shaft 4a is in mesh with a first gear 6b provided on the shaft 6a of the clutch 6. A second gear 6c is provided on the shaft 6a of the clutch 6 so as to be axially movable. A gear 25 with/from which the second gear 6c engages/disengages is provided on the outer peripheral face of the rotor 12 (on the cylindrical portion 12b of the rotor 12). When the rotation of the starter motor 4 is transmitted to the clutch 6 and causes the shaft 6a of the clutch 6 to rotate, the second gear 6c moves to engage with the gear 25 of the rotor 12. The rotational force transmitted in this manner is transmitted to the crankshaft 5 through the rotor 12.

It should be appreciated that gears in the starting mechanism provided between the starter motor and the crankshaft may be always in mesh with each other, and a one-way clutch is adapted to connect/disconnect transmission between the starter motor and the crankshaft. Alternatively, a stator motor containing a built-in clutch may be used. In brief, the clutch needs to be adapted to connect/disconnect transmission of the power between the stator motor and the crankshaft. In this embodiment, the gear 25 as an output end gear in a reduction gear train of the starting mechanism is provided on the outer periphery of the rotor 12. But, the starting mechanism is not intended to be limited to the above, so long as the mechanism is adapted to rotate the crankshaft during the starting of the engine. For example, the starter motor may be installed at the rear portion of the engine in such a manner that the output end gear in the reduction gear train is attached to the bottom portion of the rotor 12, the outer periphery of a member adapted to rotate in mesh with the crankshaft, or the crankshaft.

A sprocket 27 around which the cam chain 26 is installed is formed in the rear end portion 5a of the crankshaft body 5A protruding into the generator chamber 8 in a portion between the first extended shaft member 15 and the rear end wall 7a having the penetrating hole 14 of the crankcase 7 such that the sprocket 27 is integral with the crankshaft 5.

A front end portion 5b of the crankshaft body 5A is rotatably supported by a penetrating hole 28 formed in the front end wall 7b of the crankcase 7 and protrudes through the penetrating hole 28. The protruding portion of the front end portion 5b is covered by a sensor case 29b formed in the outer face of the front end wall 7b of the crankcase 7. A rotation sensor 29a is attached to a sensor case 29b, for detecting a member 29c mounted to the front end portion 5b. According to the detection by the rotation sensor 29a, ignition timing or the like of the engine is controlled.

According to the above-mentioned structure, the generator 3 is placed at a position corresponding to the rear end portion 5a of the crankshaft 5 of the engine 1, the starter motor 4 is placed on the outer face of the rear portion of the side wall of the crankcase 7, and the clutch 6 for connecting/disconnecting the starter motor 4 to/from the crankshaft 5 is placed in the generator chamber 8. This follows that the components 3, 4, 6 having relatively large weight are located on the rear end side of the engine 1, and the center of gravity of the engine 1 is thereby located at the rear portion of the engine 1. This is advantageous when the four-cycle engine is mounted in the personal watercraft.

The crankshaft 5 of this embodiment is comprised of the crankshaft body 5A and the first extended shaft member 15, which are connected to each other to be rotatable integrally with and separable from each other. This advantageously reduces the length of the crankshaft body 5A of a complex shape so as to be easily manufactured. In addition, since the

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rotator 12 of the generator 3 is formed integrally with the first extended shaft member 15 having the output shaft end, the generator 3 is easily placed at the rear end portion of the crankshaft, and assembly is facilitated.

FIG. 2 shows an engine 31 according to another embodiment. The engine 31 is identical in structure to the engine 1 in FIG. 1 except that a cam chain tunnel 32 is provided on the front end side of the engine 31. Therefore, the same components as those in the engine 1 in FIG. 1 are identified by the same reference numerals and will not be further described.

A front end portion 33b of a crankshaft body 33A of a crankshaft 33 of the engine 31 is rotatably supported by a penetrating hole 35 formed in a front end wall 34b of a crankcase 34. A second extended shaft member 36 is located in a front chamber 32A that defines a cam chain tunnel 32 formed in a front portion of the front end wall 34b and is connected to a tip end of the front end portion 33b in such a manner that the second extended shaft member 36 is rotatable integrally with and separable from a crankshaft body 33A. A sprocket 37 for cam chain is mounted to the second extended shaft member 36. A front end face of the crankshaft body 33A is substantially coplanar with an outer face of the front end wall 34b of the crankcase 34. A convex portion 33c for fitting is formed in the front end face of the crankshaft body 33A. A fitting hole 36a fitted over the convex portion 33c, is formed in a rear end face of the second extended shaft member 36. The convex portion 33c and the fitting hole 36a constitute so-called centering-location portion, where an outer peripheral face of the convex portion 33c is fitted to the corresponding inner peripheral face of the fitting hole 36a without substantial clearance. The fitting face is formed concentrically with a rotational center axis of the crankshaft 33.

The second extended shaft member 36 is fitted to the front end of the crankshaft body 33A and secured thereto by means of a bolt 38a. To prevent the second extended shaft 36 from rotating relatively to the crankshaft body 33A, a pin 38b for preventing rotation is attached to the front end face of the crankshaft body 33A.

A sprocket-mounting portion for mounting the cam sprocket 27 in FIG. 1 is not provided at a rear end portion 33a of the crankshaft body 33A, but instead, the first extended shaft member 15 is exteriorly fitted to a portion of the crankshaft body 33A outside a penetrating hole 14 of a crankcase 34. The rotor 12 is mounted to the first extended shaft member 15 as in the crankshaft 5 in FIG. 1. For sealing between the generator chamber 8 and an inner portion 34b of the crankcase 34, a seal member 39 is attached to the penetrating hole 14 in the rear end wall 34a of the crankcase 34. The sealing prevents an oil in the inner portion 34b of the crankcase 34 from flowing into the inside of the generator chamber 8. As a result, loss of rotational energy of the generator 8 which would be caused by viscosity of the oil is avoided.

As should be appreciated, since the sprocket-mounting portion is not provided on the rear end portion 33a of the crankshaft body 33A, the crankshaft 33 is shorter than the crankshaft 5 of the engine 1 in FIG. 1 substantially by difference between the length of the sprocket-mounting portion and the length of the seal member 39.

Reference numeral 49a denotes a sprocket for driving a scavenging pump 49b or a feed pump 49c by means of a chain 49d.

FIG. 3 shows an engine 41 according to another embodiment. The engine 41 is identical in structure to the engine 31

in FIG. 2 except for a mounting mechanism of a rotor 42. Therefore, the same components as those in FIG. 2 are identified by the same reference numerals and will not be further described.

As shown in FIG. 3, a screw portion 45a for connecting a first extended shaft member 44 and a centering-location portion 45b for causing a rotational center axis of the first extended shaft member 44 to conform to a rotational center axis of a crankshaft body 43A are formed in a rear end portion 43a of the crankshaft body 43A. The first extended shaft member 44 is provided with a connecting hole 44a for connecting the crankshaft body 43A. The connecting hole 44a has an inner thread and a fitting portion inside thereof.

A small-diameter portion 47 is formed with a step portion 46 at the rear end portion 43a of the crankshaft body 43A. The screw portion 45a and the centering location portion 45b are formed in the small-diameter portion 47. A portion 45c of the small-diameter portion 47 between the centering location portion 45b and the step portion 46 is tapered with a diameter increasing toward the step portion 46. The portion 45c is also expressed as a taper portion 45c. A rotor 42 of the generator 3 is cylindrical with a bottom. A cylindrical boss 42d having an inner peripheral face 42a to which the taper portion 45c is fitted is formed at a bottom portion of the rotor 42. The inner peripheral face 42a is tapered to allow fitting to the taper portion 45c. The rotor 42 is first fitted to the taper portion 45c, and the first extended shaft member 44 is screwed to the screw portion 45a of the small-diameter portion 47, thereby causing the rotor 42 to be pressed toward the large-diameter side of the taper portion 45c. As a result, the inner peripheral face 42a of the cylindrical boss 42d is fitted to the taper portion 45c, and thus, the rotor 42 is fixed to the taper portion 45c of the crankshaft body 43A. A magnet 42c is fixed to an inner peripheral face of a cylindrical body portion 42b like the rotor 12 in FIGS. 1 and 2.

A seal member mounting portion 14a is formed in a rear portion of the penetrating hole 14 formed in the rear end portion 48b of the crankcase 48. Between an inner peripheral face of the seal member mounting portion 14a and an outer peripheral face of the cylindrical portion 42d of the rotor 42, a seal member 39 is provided for sealing between an inside of the crankcase 48 and the generator 8.

The crankshaft 43 is shorter than the crankshaft 33 of the engine 31 in FIG. 2 substantially by difference between the length of the rivet 20 (FIG. 2) and the thickness of the flange 19 (FIG. 2). Also, since the rotor 42 is independent of the first extended shaft member 44, the first extended shaft member 54 is simply shaped.

FIG. 4 shows an engine 51 according to another embodiment. The same components as those in the engine 41 in FIG. 3 are identified by the same reference numerals and will not be further described. In the engine 51, the rotor 42 is fixed to a crankshaft body 53A by mounting a first extended shaft member 54 to a crankshaft body 53A in such a manner that a rear end portion 53a of the crankshaft body 53A is inserted into a connecting hole 54a of the first extended shaft member 54. The engine 51 does not have the second extended shaft member 36 (FIG. 3) unlike the engine 41 in FIG. 3. In addition, the centering location portion is not formed in the portion where the rear end portion 53a of the crankshaft body 53A is fitted to the first extended shaft member 54.

The rear end portion 53a is connected to the first extended shaft member 54 by means of a screw portion 55. A fitting hole 56a is formed on a rear end face of the crankshaft body

53A and a fitting hole 56b is formed on the bottom of a connecting hole 54a provided on a front end of the first extended shaft member 54. A shaft 57 for allowing a center axis of the crankshaft body 53A to conform to the center axis of the first extended shaft member 54 penetrates into the fitting holes 56a, 56b. The fitting hole 56a is concentric with the crankshaft body 53A and the fitting hole 56b is concentric with the center axis of the first extended shaft member 54. Specifically, a centering-location portion for centering the first extended shaft member 54 and the crankshaft body 53A is formed between an outer peripheral face of the shaft 57 and inner peripheral faces of the fitting holes 56a, 56b. By fittingly inserting the shaft 57 into the fitting holes 56a, 56b, the crankshaft body 53A is caused to be coaxial with the first extended shaft member 54.

With the above-mentioned structure, the crankshaft body 53A is shorter than the crankshaft body 43A in FIG. 3 substantially by the length of the centering-location portion in the rear end portion 43a.

Although the present invention has been described by way of example with reference to the accompanying drawings, it is to be understood that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the invention, they should be construed as being included therein.

What is claimed is:

1. An engine of a personal watercraft, comprising:

- a crankcase having a front end wall and a rear end wall;
- a crankshaft provided inside the crankcase;
- a generator chamber formed in a rear portion of the rear end wall of the crankcase;
- a generator provided in the generator chamber, the generator being positioned at an output end portion of the crankshaft on a rear side of the engine, the generator including a rotor mounted to a portion of the output end portion of the crankshaft;
- a coupling configured to be coupled to a propeller shaft of the watercraft, wherein the coupling is coaxially mounted outside the generator chamber and on a rear side of the rotor;
- a starter motor provided on an output end side of the crankshaft outside the crankcase;
- a clutch provided between the starter motor and the rotor of the generator, for connecting and disconnecting the starter motor to and from the rotor;
- a cam chain tunnel formed on an opposite side of the output end side of the crankshaft;
- a cam chain sprocket mounted to an end portion of the crankshaft on the opposite side of the output end side, the crankshaft passing through a penetrating hole formed in the front end wall of the crankcase and protruding into the cam chain tunnel; and
- wherein the crankshaft passes through a penetrating hole formed in the rear end wall of the crankcase and the output end portion of the crankshaft protrudes into the generator chamber; and
- wherein the output end portion of the crankshaft is configured to transmit a propulsion force for propelling the watercraft; and
- wherein a seal member is provided in the penetrating hole of the crankcase to seal between an inside of the crankcase and the generator chamber.

2. The engine of a personal watercraft according to claim 1, further comprising a water jacket formed in a housing

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constituting the generator chamber to allow cooling water to flow therethrough.

3. An engine of a personal watercraft, comprising:

a crankcase having a front end wall and a rear end wall;  
a crankshaft provided inside the crankcase;

a generator provided at an output end portion of the crankshaft, the generator including a rotor;

a starter motor provided on an output end side of the crankshaft outside the crankcase;

a clutch provided between the starter motor and the rotor of the generator, for connecting and disconnecting the starter motor to and from the rotor;

a generator chamber formed in a rear portion of the rear end wall of the crankcase, for containing the generator;

a cam chain tunnel communicating with an inside of the generator chamber;

wherein the rotor is mounted to the output end portion of the crankshaft passing through a penetrating hole formed in the rear end wall of the crankcase and protruding into the generator chamber;

a cam chain sprocket mounted to a portion of the crankshaft between the rotor and the penetrating hole;

wherein a water jacket is formed in a housing constituting the generator chamber to allow cooling water to flow therethrough.

4. An engine of a personal watercraft comprising:

a crankcase having a front end wall and a rear end wall;  
a generator chamber formed in a rear portion of the rear end wall of the crankcase, for containing a generator;

a crankshaft provided inside the crankcase, the crankshaft including a crankshaft body having one end portion passing through the rear end wall of the crankcase and protruding into the generator chamber, and a first extended shaft member contained inside the generator chamber and having one end portion connected to the one end portion of the crankshaft body so as to be rotatable integrally with and separable from the crankshaft body and an opposite end portion protruding from the generator chamber outward relative to the generator chamber; and

a rotor-mounting portion formed integrally with the first extended shaft member, for mounting a rotor of the generator;

wherein the first extended shaft member constitutes an output end part of the engine.

5. An engine of a personal watercraft, comprising:

a crankcase having a front end wall and a rear end wall;  
a generator chamber formed in a rear portion of the rear end wall of the crankcase, for containing a generator,

a crankshaft provided inside the crankcase, the crankshaft including a crankshaft body having one end portion passing through the rear end wall of the crankcase and protruding into the generator chamber, and a first extended shaft member contained inside the generator chamber and having one end portion connected to the one end portion of the crankshaft body so as to be rotatable integrally with and separable from the crankshaft body and an opposite end portion protruding from the generator chamber outward relative to the generator chamber; and

a rotor-mounting portion provided at the one end portion of the crankshaft body protruding into the generator

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chamber, for mounting a rotor of the generator, the rotor of the generator being fixed to the rotor-mounting portion by mounting the first extended shaft member to the one end portion of the crankshaft body;

wherein the first extended shaft member constitutes an output end part of the engine.

6. The crankshaft of an engine for a personal watercraft according to claim 4, further comprising a second extended shaft member connected to the other end portion of the crankshaft body to be rotatable integrally with and separable from the crankshaft body; and

a sprocket-mounting portion for mounting a cam-driving sprocket on the second extended shaft member.

7. The crankshaft of an engine for a personal watercraft according to claim 4, further comprising:

a sprocket-mounting portion formed at the one end portion of the crankshaft body adjacent the first extended shaft member, for mounting a cam-driving sprocket of the engine.

8. The crankshaft of an engine for a personal watercraft according to claim 4, wherein

a connecting hole is formed in an end portion of the first extended shaft member for connecting the crankshaft body by inserting the one end portion of the crankshaft body therinto,

an outer peripheral face of the one end portion of the crankshaft body and an inner peripheral face of the connecting hole of the first extended shaft member respectively have a cylindrical fitting face for centering and an engagement portion for preventing circumferential relative rotation between the crankshaft body and the first extended shaft member, and

a center axis of the fitting face of the crankshaft body corresponds with a rotational center axis of the crankshaft and a center axis of the fitting face of the first extended shaft member corresponds with a center axis of the first extended shaft member.

9. The crankshaft of an engine for a personal watercraft according to claim 5, further comprising a second extended shaft member connected to the other end portion of the crankshaft body to be rotatable integrally with and separable from the crankshaft body; and

a sprocket-mounting portion for mounting a cam-driving sprocket on the second extended shaft member.

10. The crankshaft of an engine for a personal watercraft according to claim 5, wherein

a connecting hole is formed in an end portion of the first extended shaft member for connecting the crankshaft body by inserting the one end portion of the crankshaft body therinto,

an outer peripheral face of the one end portion of the crankshaft body and an inner peripheral face of the connecting hole of the first extended shaft member respectively have a cylindrical fitting face for centering and an engagement portion for preventing circumferential relative rotation between the crankshaft body and the first extended shaft member, and

a center axis of the fitting face of the crankshaft body corresponds with a rotational center axis of the crankshaft and a center axis of the fitting face of the first extended shaft member corresponds with a center axis of the first extended shaft member.